

Optimal Location and Sizing of DG using Fuzzy logic

Sujata Huddar¹, B. Kantharaj², K. R. Mohan³, S. B. Patil⁴, Rudresh Magadam⁵

¹(PG scholar Department of Electrical & Electronics Engg A.I.T Chikmagalur, Karnataka, India)

^{2, 3} (Associate professor Department of Electrical & Electronics Engg A.I.T Chikmagalur, Karnataka, India)

⁴(Assistant professor Department of Electrical & Electronics Engg H.I.T Nidasoshi, Karnataka, India)

⁵(Assistant professor Department of Electrical & Electronics Engg G.I.T Belgaum, Karnataka, India)

Abstract: Introduction of distributed generation modifies the structure of power system network. High levels of penetration of distributed generation (DG) are new challenges for traditional electric power systems. A power injection from DG units modifies network power flows, changes energy losses and improves voltage profile of the system. Proper locations of DG units in power systems are very important in order to obtain maximum potential advantages. There are some of the most popular DG placement methods, such as Optimal Power Flow, 2/3 Rule and Evolutionary Computational Methods. The Evolutionary computational method includes Genetic Algorithm, Fuzzy Systems and Tabu Search. In this paper we have considered the Fuzzy logic method for the optimal location and sizing of DG.

The optimal placement of DG is necessary to improve the reliability and stability. Proposed method is tested by considering IEEE 33 bus system data. The Fuzzy logic method includes a fuzzy inference system (FIS) containing a set of rules which are considered to determine the DG placement suitability index of each node in the distribution system. The optimal sizing of DG unit is obtained with the help of mathematical expressions.

Keywords: Distributed Generation (DG); Fuzzy logic; Fuzzy rule; Optimal Location; Optimal Power flow.

I. INTRODUCTION

Distributed generation is defined as small scale generation which is not directly connected to the bulk transmission system & it is not centrally dispatched. Distributed generation is connected at the distribution level which leads to the many changes in the characteristics of distribution network. The proper location of DG plays a very important role to upgrade the system reliability and stability, to reduce the system losses, to improve the system voltage profile [1]. At present the number of scholars are carry the work on placement of DG here the reference [2] considers the case of single radial feeder with the three load conditions namely uniform load, concentrated load, increasing load for which the optimal location of DG is found with the analytical approaches to minimize the losses in the single radial feeder. The optimal location of DG is needed to increase the distributed generation potential benefits in the power system. There are many methods for the proper location and sizing DG, some of the methods are explained in reference [3]. Such as Evolutionary computational method [including genetic algorithm, fuzzy logic, & tabu search], 2/3 Rule, optimal power flow. Reference [4] shows the consideration of Fuzzy rules for the proper location of capacitor. In case of Fuzzy logic a set of Fuzzy rules are considered for the proper placement of DG by considering the VSI and PLI as an input to the system and output as DGSI. The mathematical equations are used to calculate the sizing of DG [5].

The reference [6] shows the optimal placement of DG units using Fuzzy & real coded Genetic algorithm, Any how the research work is continuous to upgrade the network losses, improve the voltage stability and reliability of the power system. In this paper we have considered the fuzzy logic method for the optimal location and sizing of DG. Proposed method is tested by considering the IEEE33 bus system data, before obtaining location and sizing, the load flow analysis is performed by considering the NR method.

II. INTRODUCTION TO FUZZY LOGIC

First consider the given system data then conduct the load flow analysis, from which we get the PLI (power loss indices) & VSI (voltage sensitivity indices). The PLI & VSI are used as the inputs to the Fuzzy interfacing system after Fuzzification & defuzzification we get the output DGSI (distributed generator sensitivity index). The ranges of VLI, PLI, and DGSI are considered from the load flow analysis. For example let us consider the range of PLI is 0 to 1, The VLI ranges from 0.9 to 1.1 and the output DGSI varies from 0 to 1. The variables for these ranges are described with the help of five membership functions they are high, high medium, medium, and low medium, low. The membership functions of PLI & DGSI are triangular in shape & where as

the VSI membership functions are combination of both triangular & trapezoidal in shape, these are graphically shown as follows.

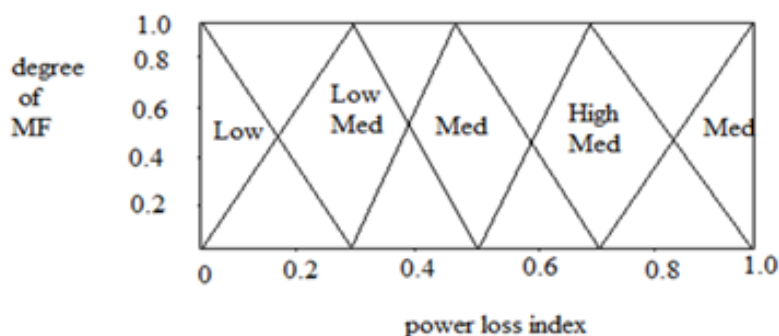


Fig 1 Power loss index membership function

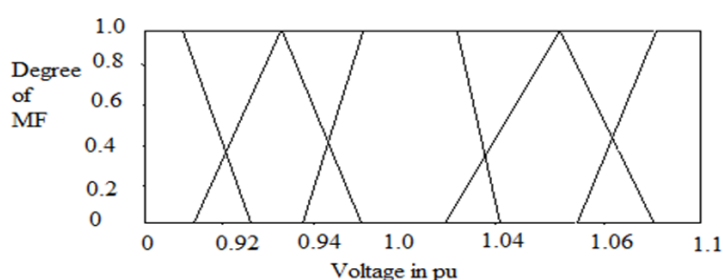


Fig 2 Voltage membership function

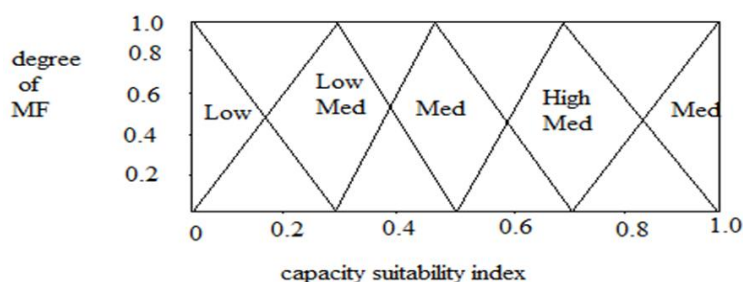


Fig 3 Distributed generator suitability index membership function

To determine the best DG placement problems certain rules are defined in order to determine the suitability index of bus. For DG installation the rules are summarized in the fuzzy decision matrix as shown below.

AND		VSI				
		L	LN	N	HN	H
PLI	L	LM	LM	L	L	L
	LM	M	LM	LM	L	L
	M	HM	M	LM	L	L
	HM	HM	HM	M	LM	L
	H	H	HM	M	LM	LM

Table1 matrix to determine the DG suitability index

III. DETERMINATION OF SENSITIVE BUSES FOR THE OPTIMAL

IV. LOCATION OF DG FOR 33BUS SYSTEM

Bus no	VSI	PLI	DGSI
1	1.00	0	0.49
2	0.9952	0.0198	0.5
3	0.9725	0.0839	0.471

4	0.9601	0.0342	0.425
5	0.9479	0.0322	0.404
6	0.9317	0.0152	0.366
7	0.9259	0.0033	0.376
8	0.9178	0.0084	0.382
9	0.9074	0.0073	0.402
10	0.8976	0.0062	0.404
11	0.8962	0.0010	0.4
12	0.8937	0.0015	0.4
13	0.8835	0.0047	0.395
14	0.8797	0.0013	0.39
15	0.8773	0.0006	0.387
16	0.8750	0.0005	0.384
17	0.8716	0.0004	0.381
18	0.8706	0.0001	0.38
19	0.9944	0.0003	0.498
20	0.9886	0.0013	0.491
21	0.9875	0.0002	0.49
22	0.9864	0.0001	0.442
23	0.9667	0.0053	0.462
24	0.9558	0.0086	0.415
25	0.9504	0.0021	0.403
26	0.9285	0.0045	0.374
27	0.9242	0.0058	0.375
28	0.9051	0.0136	0.421
29	0.8914	0.0068	0.403
30	0.8855	0.0028	0.396
31	0.8785	0.0004	0.388
32	0.8770	0.0001	0.386
33	0.8755	0.0196	0.432

Table 2 DGSI output from the Fuzzy system

Result: The above table shows that maximum value of Distributed generation sensitivity index is at bus 2 with DGSI= 0.5, Therefore the best location of DG is at bus 2.

Improvement Of Voltage Profile With DG

Bus No	Without DG	With DG
	Voltage in P.U	Voltage in P.U
1	1.0000	1.0000
2	0.9952	0.9968
3	0.9725	0.9826
4	0.9601	0.9714
5	0.9479	0.9604
6	0.9317	0.9461
7	0.9259	0.9409
8	0.9178	0.9337
9	0.9074	0.9244
10	0.8976	0.9159
11	0.8962	0.9146
12	0.8937	0.9124
13	0.8835	0.9034

14	0.8797	0.9001
15	0.8773	0.8980
16	0.8750	0.8960
17	0.8716	0.8931
18	0.8706	0.8922
19	0.9944	0.9959
20	0.9886	0.9903
21	0.9875	0.9891
22	0.9864	0.9881
23	0.9667	0.9844
24	0.9558	0.9866
25	0.9504	1.000
26	0.9285	0.9432
27	0.9242	0.9394
28	0.9051	0.9226
29	0.8914	0.9104
30	0.8855	0.9052
31	0.8785	0.8991
32	0.8770	0.8977
33	0.8755	0.8964

Table3 Bus voltages with & without DG

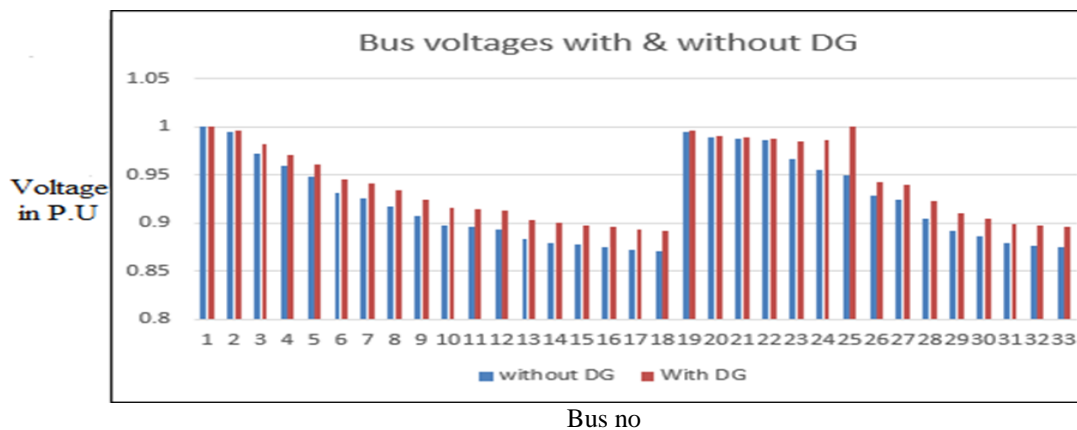


Fig 4 Bus voltages with & without DG

V. PROCEDURE TO CALCULATE THE OPTIMAL SIZE OF DG

First let us consider the drawn system diagram in which the DG is placed at the bus i , which produces the current of I_{DG} . In a radial distribution system the current I_{DG} changes for the current branches which are connected to bus i , where as the current of other branches are unchanged.

Therefore new current I_k' of the k^{th} branch is given by

$$I_k' = I_k + A_k I_{DG} \quad (1)$$

Where $A_k = 1$ if K^{th} branch which is connected to bus i otherwise $A_k = 0$

The value of current I_{DG} can be calculated with the help of following equation

$$I_{DG} = - \frac{\sum_{k=1}^{n_{bus}-1} (A_k I_k R_k)}{\sum_{k=1}^{n_{bus}-1} (A_k)^2 R_k} \quad (2)$$

Now the size of DG is calculated by considering the following equation

$$S_{DG} = V_i I_{DG} \quad (3)$$

Where V_i = Voltage at the i^{th} bus

VI. CONCLUSION

In this paper we have considered optimal location & sizing of DG using Fuzzy logic. Optimal location of DG is obtained using Fuzzy logic and optimal size of DG is calculated by analytical method which are helpful to upgrade the loss minimization and improvement of voltage profile. Finally we can conclude that proper location & sizing of DG is better to improve the voltage profile, reduction in the losses and helps to improve the overall system stability.

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APPENDIX

IEEE 33 Bus system

A. Line data for IEEE 33 Bus system

BASE: 12.66 kV, 100MVA

Sending bus	Receiving bus	R (in ohm)	X (in ohm)
1	2	0.09220	0.04700
2	3	0.49300	0.25110
3	4	0.36600	0.18640
4	5	0.38110	0.19410
5	6	0.81900	0.70700
6	7	0.01872	0.61880
7	8	0.71140	0.23510
8	9	1.03000	0.74000
9	10	1.04400	0.74000
10	11	0.19660	0.06500
11	12	0.37440	0.12380
12	13	1.46800	1.15500
13	14	0.54160	0.71290
14	15	0.59100	0.52600
15	16	0.74630	0.54500
16	17	1.28900	1.72100
17	18	0.73200	0.57400
2	19	0.16400	0.15650
19	20	1.50420	1.35540
20	21	0.40950	0.48740
21	22	0.70890	0.93730
3	23	0.45120	0.30830
23	24	0.89800	0.70910
24	25	0.89600	0.70110
6	26	0.20300	0.10340
26	27	0.20420	0.14470
27	28	1.05900	0.93370
28	29	0.80420	0.70060

29	30	0.50750	0.25850
30	31	0.97440	0.96300
31	32	0.31050	0.36190
32	33	0.34100	0.53020

B. Load data for IEEE 33Bus system

Bus No	Bus code	Load Data	
		K W	KVAR
1	1	-	-
2	0	100	60
3	0	90	40
4	0	120	80
5	0	60	30
6	0	60	20
7	0	200	100
8	0	200	100
9	0	60	20
10	0	60	20
11	0	45	30
12	0	60	35
13	0	60	35
14	0	120	80
15	0	60	10
16	0	60	20
17	0	60	20
18	0	90	40
19	0	90	40
20	0	90	40
21	0	90	40
22	0	90	40
23	0	90	50
24	0	420	200
25	0	420	200
26	0	60	25
27	0	60	25
28	0	60	20
29	0	120	70
30	0	200	600
31	0	150	70
32	0	210	100
33	0	60	40